

WHAT IS CLAIMED IS:

1. A packet switch comprising:

a packet divider for dividing variable-length packets from a plurality of input lines into
5 fixed-length packets;

a plurality of input buffer sections provided corresponding to the plurality of input lines, each input buffer section having queues provided for each of mutually different priorities of a smaller number than
10 that of QoS classes that can be designated, and for each of a plurality of output lines, for registering fixed-length packets from corresponding input lines to corresponding queues according to the output line and the QoS class;

15 a scheduler for reading the fixed-length packets registered in the queues of the input buffer sections according to the priority given to each queue so that two or more fixed-length packets of the same output line are not read out within a unit time;

20 a switch for routing each fixed-length packet read out by the scheduler to a designated one output line out of the plurality of output lines; and

a plurality of output buffer sections provided corresponding to the plurality of output lines,
25 for carrying out an assembling of a variable-length packet from the fixed-length packets output from the switch and for controlling the priority based on the QoS class.

2. The packet switch of Claim 1, wherein

30 each input buffer section has a queue of a first priority and a queue of a second priority for each output line,

a packet of a bandwidth guaranteed class is registered in the queue of the first priority,

35 a packet of a best effort class is registered in the queue of the second priority,

a packet of a minimum bandwidth guaranteed

2025 RELEASE UNDER E.O. 14176

class is registered in the queue of the second priority,
and

the queue of the second priority has a
first drop level for dropping a packet of the minimum
5 bandwidth guaranteed class that has been input in excess
of a designated bandwidth and a packet of the best effort
class, and a second drop level higher than the first drop
level for dropping a packet of the minimum bandwidth
guaranteed class that has been input within a designated
10 bandwidth.

3. The packet switch of Claim 1, wherein
each output buffer section includes:
a variable-length packet assembling buffer
having queues of a number equal to the number of queues
15 for each output line in each input buffer section, for
each input line, for storing fixed-length packets output
from the switch into corresponding queues according to
the input line, thereby to assemble variable-length
packets from the fixed-length packets; and
20 a QoS control section having queues of a
number equal to the number of QoS classes that can be
designated, for registering the variable-length packets
assembled by the variable-length packet assembling buffer
into corresponding queues according to a QoS class, and
25 for sequentially reading the variable-length packets
according to a packet length and the QoS class and
outputting the read variable-length packets to
corresponding output lines.

4. The packet switch of Claim 1, wherein
30 each output buffer section includes:
a fixed-length-based QoS control section
having queues of a number equal to the number of QoS
classes that can be designated, for registering fixed-
length packets output from the switch into corresponding
35 queues according to the QoS class; and
a variable-length packet assembling buffer
having queues of a number equal to the number of QoS

classes that can be designated for each input line, for registering the fixed-length packets output from the fixed-length-based QoS control section into corresponding queues according to the input line and the QoS class thereby to assemble variable-length packets, and for transferring the assembled variable-length packets to a corresponding output line.

5 The packet switch of Claim 1, wherein
 the scheduler selects fixed-length
10 packets, one by one, that are to be output to each output line, by checking all the queues within the plurality of input buffer sections in the order of priorities given to the queues, in a predetermined order of input lines and in a predetermined order of output lines, respectively,
15 within a unit time, and

 in selecting an output line for transmitting a fixed-length packet from the queue of the same priority and the same input line, the scheduler selects with priority over other fixed-length packets,
20 the fixed-length packet within the queue that corresponds to the output line from which a part of a plurality of fixed-length packets that constitute a variable-length packet has already been transmitted.

6. The packet switch of Claim 3, wherein
25 the QoS control section includes:
 means for adding a first value to a corresponding token when a variable-length packet has reached the front of one of the queues;

 means for subtracting a second value from
30 each of tokens of active QoS classes each time when a unit time has passed; and

 means for starting the reading of a variable-length packet of which corresponding token is a minimum or 0 among the active QoS classes when a packet
35 can be sent to the output line.

7. The packet switch of Claim 6, wherein the first value is a value corresponding to a packet length of the

variable-length packet that has reached the front of the queue, and the second value is a value corresponding to a ratio of a weight of each active QoS class to a total sum of the weights of the active QoS classes.

5 8. The packet switch of Claim 6, wherein the first value is a value corresponding to a product of a packet length of the variable-length packet that has reached the front of the queue and a total sum of the weights of the active QoS classes, and the second value is a value
10 corresponding to a weight of each active QoS class.

 9. The packet switch of Claim 8, wherein the first-value adding means adds the total sum of the weights of the active QoS classes to the token each time when a unit time has passed, and repeats this addition by
15 the number corresponding to the packet length, thereby adding the first value.

 10. The packet switch of Claim 3, wherein
 the QoS control section includes:
 a counter for counting for each QoS class
20 a number of fixed-length packets composing variable-length packets;
 a priority control section for determining and posting a QoS class of a packet to be output with priority based on a constant packet length, from out of
25 QoS classes that have count values other than 0; and
 a variable-length packet managing section for counting the posts from the priority control section for each QoS class, reading out a variable-length packet of the QoS class of which count value has reached a value
30 corresponding to the packet length of the variable-length packet at the front of a corresponding queue, and sending the read variable-length packet to the output line.

 11. The packet switch of Claim 3, wherein
 the QoS control section includes:
35 a first counter for counting for each QoS class a number of fixed-length packets composing variable-length packets of the bandwidth guaranteed class

and variable-length packets of the minimum bandwidth guaranteed class that have been input within a designated bandwidth;

5 a second counter for counting for each QoS class a number of fixed-length packets composing variable-length packets of the best effort class and variable-length packets of the minimum bandwidth guaranteed class that have been input in excess of the designated bandwidth;

10 a priority control section for determining and posting a QoS class of a packet to be output with priority based on a constant packet length, from out of QoS classes that have count values other than 0 for the first counter and QoS classes that have count values
15 other than 0 for the second counter; and

 a variable-length packet managing section for counting the posts from the priority control section for each QoS class, reading out a variable-length packet of the QoS class of which the count value has reached a
20 value corresponding to the packet length of the variable-length packet at the front of a corresponding queue, and sending the read variable-length packet to the output line.

12. The packet switch of Claim 6, wherein
25 the second value includes a second value for bandwidth guaranteed fraction and a second value for best effort fraction, and

 the second-value subtracting means subtracts only the second value for the bandwidth guaranteed fraction from the token when there has been a
30 packet reading from a bandwidth guaranteed class, and subtracts the second value for the bandwidth guaranteed fraction and the second value for the best effort fraction from the token when there has been no reading
35 from the bandwidth guaranteed class.

13. The packet switch of Claim 6, wherein
 the token includes a token for bandwidth

guaranteed fraction and a token for best effort fraction, and the second value includes a second value for the bandwidth guaranteed fraction and a second value for the best effort fraction.

5 the second-value subtracting means subtracts the second value for the bandwidth guaranteed fraction and the second value for the best effort fraction from the token for the bandwidth guaranteed fraction and the token for the best effort fraction
10 respectively, and

 when a packet to be read out has been selected based on one of the token for the bandwidth guaranteed fraction and the token for the best effort fraction, the value subtracted from the other token is
15 carried forward to the token of the next packet.

14. A scheduling device comprising:

 queues provided in a number equal to a number of QoS classes that can be designated, for registering variable-length packets according to a QoS
20 class;

 means for adding a first value to a corresponding token when a variable-length packet has reached a front of one of the queues;

 means for subtracting a second value from each of tokens of active QoS classes each time when a unit time has passed; and

 means for starting the reading of a variable-length packet of which corresponding token is a minimum or 0 among the active QoS classes when a packet
30 can be sent to the output line.

15 15. The scheduling device of Claim 14, wherein the first value is a value corresponding to a packet length of the variable-length packet that has reached the front of the queue, and the second value is a value
35 corresponding to a ratio of a weight of each active QoS class to a total sum of the weights of the active QoS classes.

16. The scheduling device of Claim 14, wherein the first value is a value corresponding to a product of a packet length of the variable-length packet that has reached the front of the queue and a total sum of the weights of the active QoS classes, and the second value is a value corresponding to a weight of each active QoS class.

17. The scheduling device of Claim 16, wherein the first-value adding means adds the total sum of the weights of the active QoS classes to the token each time when a unit time has passed, and repeats this addition by the number corresponding to the packet length, thereby adding the first value.

18. A scheduling device comprising:
queues provided in a number equal to a number of QoS classes that can be designated, for registering variable-length packets according to a QoS class;
a counter for counting for each QoS class a number of fixed-length packets composing variable-length packets;
a priority control section for determining and posting a QoS class of a packet to be output with priority based on a constant packet length, from out of QoS classes that have count values other than 0; and
a variable-length packet managing section for counting the posts from the priority control section for each QoS class, reading out a variable-length packet of the QoS class of which count value has reached a value corresponding to the packet length of the variable-length packet at the front of a corresponding queue, and sending the read variable-length packet to the output line.

19. A scheduling device comprising:
queues provided in a number equal to a number of QoS classes that can be designated, for registering variable-length packets according to a QoS class;

2025 RELEASE UNDER E.O. 14176

5 a first counter for counting for each QoS class a number of fixed-length packets composing variable-length packets of the bandwidth guaranteed class and variable-length packets of the minimum bandwidth guaranteed class that have been input within a designated bandwidth;

10 a second counter for counting for each QoS class a number of fixed-length packets composing variable-length packets of the best effort class and variable-length packets of the minimum bandwidth guaranteed class that have been input in excess of the designated bandwidth;

15 a priority control section for determining and posting a QoS class of a packet to be output with priority based on a constant packet length, from out of QoS classes that have count values other than 0 for the first counter and QoS classes that have count values other than 0 for the second counter; and

20 a variable-length packet managing section for counting the posts from the priority control section for each QoS class, reading out a variable-length packet of the QoS class of which count value has reached a value corresponding to the packet length of the variable-length packet at a front of a corresponding queue, and sending
25 the read variable-length packet to the output line.

20. The scheduling device of Claim 14, wherein the second value includes a second value for bandwidth guaranteed fraction and a second value for best effort fraction, and

30 the second-value subtracting means subtracts only the second value for the bandwidth guaranteed fraction from the token when there has been a packet reading from the bandwidth guaranteed class, and subtracts the second value for the bandwidth guaranteed
35 fraction and the second value for the best effort fraction from the token when there has been no reading from the bandwidth guaranteed class.

21. The scheduling device of Claim 14, wherein
the token includes a token for bandwidth
guaranteed fraction and a token for best effort fraction,
and the second value includes a second value for
5 bandwidth guaranteed fraction and a second value for best
effort fraction,

the second-value subtracting means
subtracts the second value for the bandwidth guaranteed
fraction and the second value for the best effort
10 fraction from the token for the bandwidth guaranteed
fraction and the token for the best effort fraction
respectively, and

when a packet to be read out has been
selected based on one of the token for the bandwidth
15 guaranteed fraction and the token for the best effort
fraction, the value subtracted from the other token for
the selected packet is carried forward to the token of a
next packet.

22. A drop control circuit comprising:

20 a calculation circuit for multiplying a
difference between a volume of packets stored in a buffer
and a threshold value thereof to a packet length of a
variable-length packet existing at a front of the buffer,
and outputting a result of the multiplication;

25 a register;

an adder circuit for adding a calculation
result of the calculation circuit to the register; and

30 a control circuit for dropping at once a
variable-length packet that exists at the front of the
buffer when a register value has exceeded a predetermined
value, and subtracting from the register a value obtained
by multiplying the packet length by the predetermined
value.

23. A drop control circuit comprising:

35 a calculation circuit for outputting a
difference between a volume of packets stored in a buffer
and a threshold value thereof;

a register;
an adder circuit for adding a calculation
result of the calculation circuit to the register; and
a control circuit for dropping a fixed-
5 length packet that exists at a front of the buffer when a
register value has exceeded a predetermined value, and
subtracting the predetermined value from the register.

24. A multicast control circuit comprising:
a multicast queue for registering an
10 address of a variable-length packet to be multicast-
controlled that is stored in a buffer;
a plurality of output buffer queues
provided corresponding to a plurality of output lines;
an address management table for managing
15 the address of a variable-length packet stored in the
buffer; and
control means for storing as many records
as there are output destinations into the address
management table, each record including the address of
20 the variable-length packet, and for registering addresses
of the records in the output buffer queues corresponding
to the output destinations, when the address of the
variable-length packet to be multicast-controlled has
been registered in the multicast queue.

25 25. A packet switch for switching a variable-length
packet having a QoS class, the packet switch comprising:
means for mapping a plurality of QoS
classes into simple priority classes; and
means for controlling the reading of the
30 variable-length packets based on the simple priority
classes.

26. A packet switch for converting an IP packet
that has a QoS class into fixed-length packets, for
switching the IP packet on the basis of the fixed-length
35 packets, the packet switch comprising:
means for mapping priority classes of IP
packets into simple priority classes of a smaller number

5

10

15

20

25

30

35

29. The QoS control device of Claim 28, wherein
a packet of a bandwidth guaranteed class
and a packet of a minimum bandwidth guaranteed class that
has been input within a designated bandwidth belong to
the high-priority group, and a packet of a best effort
class and a packet of the minimum bandwidth guaranteed
class that has been input in excess of the designated

bandwidth belong to the low-priority group, and
the packet of the minimum bandwidth
guaranteed class is selected in the order of arrival
irrespective of whether the packet has been selected as a
5 packet within the designated bandwidth by the first
selector or whether the packet has been selected as a
packet outside the designated bandwidth by the second
selector.

30. The QoS control device of Claim 28, wherein
10 each of the first and second selectors selects one QoS
class by round robin.

31. The QoS control device of Claim 28, wherein
each of the first and second selectors selects a QoS
class of a packet that has arrived the earliest.

32. The QoS control device of Claim 28, wherein
15 each of the first and second selectors selects one QoS
class out of packets that have arrived during an oldest
period and that have not yet been selected.

33. The QoS control device of Claim 28, wherein
20 each of the first and second selectors selects one QoS
class according to a volume of packets that have not yet
been selected.

34. A packet switch having a plurality of input
lines for receiving packets and a plurality of output
25 lines for sending packets, comprising:

a plurality of input buffer sections
provided corresponding to the plurality of input lines,
each input buffer section having queues provided for each
of a plurality of output lines and for each of designated
30 QoS classes, and for registering packets from
corresponding input lines to corresponding queues
according to the output line and a QoS class;

a scheduler for controlling the reading
the packets registered in the queues of the input buffer
35 sections so that two or more packets of the same output
line are not read out within a unit time;

a switch for routing each packet read out

to a designated one output line out of the plurality of output lines; and

5 a plurality of output buffer sections provided corresponding to the plurality of output lines, for controlling the sending of the switched packet to the designated one output line according to a priority based on the QoS class.

35. The packet switch of Claim 34, wherein
10 each input buffer section has a queue of a first priority and a queue of a second priority for each output line, and

each of said designated QoS classes is mapped into one of said first priority queue and said second priority queue.

15 36. The packet switch of Claim 35, wherein
a packet of a bandwidth guaranteed class is registered in the first priority queue,

a packet of a best effort class is registered in the second priority queue,

20 a packet of a minimum bandwidth guaranteed class is registered in the second priority queue, and

the second priority queue has a first drop level for dropping a packet of the minimum bandwidth guaranteed class that has been input in excess of a designated bandwidth and a packet of the best effort class, and a second drop level higher than the first drop level for dropping a packet of the minimum bandwidth guaranteed class that has been input within a designated bandwidth.

30 37. The packet switch of Claim 34, wherein
each output buffer section includes:

a QoS control section having queues of a number equal to a number of QoS classes that can be designated, for registering the packets into

35 corresponding queues according to a QoS class, and for sequentially reading the packets according to a packet length and a QoS class and outputting the read packets to

corresponding output lines.

38. The packet switch of Claim 37, wherein
the QoS control section includes:

5 means for adding a first value to a
corresponding token when a packet has reached a front of
one of the queues;

means for subtracting a second value from
each of tokens of active QoS classes each time when a
unit time has passed; and

10 means for starting the reading of a packet
of which corresponding token is a minimum or 0 among the
active QoS classes when a packet can be sent to the
output line.

39. The packet switch of Claim 38, wherein the
15 first value is a value corresponding to a packet length
of the packet that has reached the front of the queue,
and the second value is a value corresponding to a ratio
of a weight of each active QoS class to a total sum of
the weights of the active QoS classes.

20 40. The packet switch of Claim 38, wherein the
first value is a value corresponding to a product of a
packet length of the packet that has reached the front of
the queue and a total sum of the weights of the active
QoS classes, and the second value is a value
25 corresponding to a weight of each active QoS class.

41. The packet switch of Claim 40, wherein the
first-value adding means adds the total sum of the
weights of the active QoS classes to the token each time
when a unit time has passed, and repeats this addition by
30 the number corresponding to the packet length, thereby
adding the first value.

42. A packet switch for switching packets each
packet having a QoS class, the packet switch comprising:
means for mapping a plurality of different
35 QoS classes into simple priority classes where a quantity
of simple priority classes is less than a quantity of the
plurality of different QoS classes; and

means for controlling the switching of the packets based on the simple priority classes.

43. A packet switch for converting an IP packet that has a QoS class into fixed-length packets, for
5 switching the IP packet on the basis of the fixed-length packets, the packet switch comprising:

means for mapping priority classes of IP packets into simple priority classes of a smaller number than the number of QoS classes that are allocated to the
10 IP packets;

means for controlling the switching of the fixed-length packets based on the simple priority classes; and

means for controlling the sending of the
15 IP packets after switching based on the QoS classes allocated to the IP packets.

44. A method for switching packets in a packet switch having a plurality of input lines for receiving packets and a plurality of output lines for sending
20 packets, comprising:

storing packets from the plurality of input lines to a plurality of input buffer sections provided corresponding to the plurality of input lines, each input buffer section having queues provided for each
25 of a plurality of output lines and for each of designated QoS classes, and where packets from corresponding input lines are stored to corresponding queues according to the output line and a QoS class;

reading the packets stored in the queues
30 of the input buffer sections so that two or more packets of the same output line are not read out within a unit time;

switching each packet read out to a designated one output line out of the plurality of output
35 lines; and

sending the switched packet to the designated one output line according to a priority based

on the QoS class.

45. The method of Claim 44, further comprising:

mapping each of the designated QoS classes
into one of a first priority queue and a second priority
5 queue wherein each input buffer section has a queue of a
first priority and a queue of a second priority for each
output line, and

46. The method of Claim 45, further comprising:

10 storing a packet of a bandwidth guaranteed
class in the queue of the first priority,

storing a packet of a best effort class in
the queue of the second priority,

storing a packet of a minimum bandwidth
guaranteed class in the queue of the second priority, and

15 dropping a packet of the minimum bandwidth
guaranteed class that has been input in excess of a
designated bandwidth and a packet of the best effort
class when a first drop level of the queue of the second
priority is reached, and dropping a packet of the minimum
20 bandwidth guaranteed class that has been input within a
designated bandwidth when a second drop level higher than
the first drop level is reached.

47. The method of Claim 44, wherein:

25 in the sending step the switched packet is
sent to the designated one output line further according
to a packet length.

48. A method of scheduling reading of packets
belonging to a QoS class to be output from a packet
switch, comprising:

30 storing packets according to the QoS class
of the packet in queues provided in a number equal to a
number of different QoS classes that can be designated;

adding a first value to a corresponding
token when a packet has reached a front of one of the
35 queues;

subtracting a second value from each of
tokens of active QoS classes each time when a unit time

has passed; and

starting the reading of a packet of which corresponding token is a minimum or 0 among the active QoS classes when a packet can be sent to the output line.

5 49. The method of Claim 48, wherein the first value is a value corresponding to a packet length of a packet that has reached the front of the queue, and the second value is a value corresponding to a ratio of a weight of each active QoS class to a total sum of the weights of
10 the active QoS classes.

50. The method of Claim 48, wherein the first value is a value corresponding to a product of a packet length of a packet that has reached the front of the queue and a total sum of weights of the active QoS classes, and the
15 second value is a value corresponding to a weight of each active QoS class.

51. The method of Claim 50, wherein the first-value adding step adds the total sum of the weights of the active QoS classes to the token each time when a unit
20 time has passed, and repeats this addition by the number corresponding to the packet length, thereby adding the first value.

52. A method of selecting a packet to be switched in a packet switch comprising the steps of:

25 mapping a plurality of different QoS classes designated for packets to be switched into a high-priority group and a low-priority group;

 selecting a QoS class of the high-priority group for reading a packet belonging to the selected QoS
30 class of the high-priority group;

 selecting a QoS class of the low-priority group for reading a packet belonging to the selected QoS class of the low-priority group; and

 selecting one of the high-priority group
35 and the low-priority group, thereby selecting for reading one of the selected packet belonging the high-priority group and the low-priority group.